Ocean Dynamics

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LONG-TERM GOALS

To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through intercomparison of high, mid- and low-latitude observations, both near the sea surface, in the main thermocline, and near the sea floor.

OBJECTIVES

To identify the phenomena involved in the cascade of energy from mesoscales to turbulent scales. To quantify the relationship between fine-scale background conditions and the occurrence of microscale breaking.

APPROACH

Progress is effected through a steady-state cycle of instrument development, field observation and data analysis. The primary instruments employed include Doppler sonar and profiling CTD's. Generically, our instruments produce information which is quasi-continuous in space and time. Measurements typically span two decades in the wavenumber domain. This broad band space-time coverage enables the investigation of multi-scale interactions.

WORK COMPLETED

We are completing an extensive study of Arctic internal waves and eddies based on data from the ONR SIMI (1993-4) experiment. Observations are from a 161 kHz coded pulse Doppler sonar (Fall 1992) and a RDI 150 kHz narrowband ADCP Winter (1992-3).

RESULTS

The over-winter SIMI observations gave us the opportunity to monitor a number of sub-mesoscale coherent vortices (eddies) in the central Beaufort Sea. There is considerable controversy over the formation process of these eddies and their subsequent evolution and decay. Student Chris Halle (PhD completed February 02) compared the aspect ratio and rotation rate of these eddies with similar measurement from low-latitude eddies and from the laboratory measurements of Hedstrom and Armi 1988 (Figure 1). While there is some latitude in the precise definition of “aspect ratio”, it generally appears that the arctic eddies either rotate slightly slower or are slightly broader than their laboratory counterparts. Given the observational uncertainties, we feel that the overall agreement with the

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14. ABSTRACT
To gain a more complete understanding of ocean dynamical processes, particularly at fine-scale, through intercomparison of high, mid- and low-latitude observations, both near the sea surface, in the main thermocline, and near the sea floor.

15. SUBJECT TERMS

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Hedstrom-Armi result is still quite remarkable. A specific consequence of the finding is that there is no need to invoke frictional spinning from flow down a canyon to impart the vorticity observed in eddy cores. The simple spin-up of an injected lense of fluid is more than ample to account for the observed vorticity.

Focusing on the dissipative aspects of an arctic eddy, Halle was able to estimate a Richardson number field for some of the features. The effort was interesting in that nearly half the shear associated with an eddy is contributed by near inertial waves that are trapped above and below the outer flanks of the eddy (Figure 2). Parameterized estimates of the dissipation can be made (Gregg 1989), but they beg the question whether it's the waves or the eddy that is dissipating.

IMPACT/APPLICATIONS

These eddies, which comprise 20-40% of the volume of Pacific Layer and related waters in the Central Beaufort Sea, strongly modulate the flow of energy between the sea surface and the warm Atlantic waters which lie ~200 m below. One expects that patterns of vertical mixing are modulated as well and that small scale variations in sound speed are also enhanced in regions of wave build-up.

TRANSITIONS

Work has been submitted to JGR for publication.

RELATED PROJECTS

The SIMI observations are being compared with the subsequent data from the NSF SHEBA experiment. Between the two experiments a coherent picture of the wavefield in the Western Arctic is beginning to emerge.

PUBLICATIONS

Alford, M.H., R. Pinkel, 2000: Observations of overturning in the thermocline: The context of ocean mixing. J. Phys. Oceanogr., 30, 805-832

Alford, M.H., R. Pinkel, 2000: Patterns of Turbulent and Double-Diffusive Phenomena: Observations from a Rapid-Profiling Microconductivity Probe. J. Phys. Oceanogr., 30, 833-854

Halle, C.M. and R. Pinkel, 2003: Internal wave variability in the Beaufort Sea during the winter of 1993/94. J. Geophys. Res. In Press.

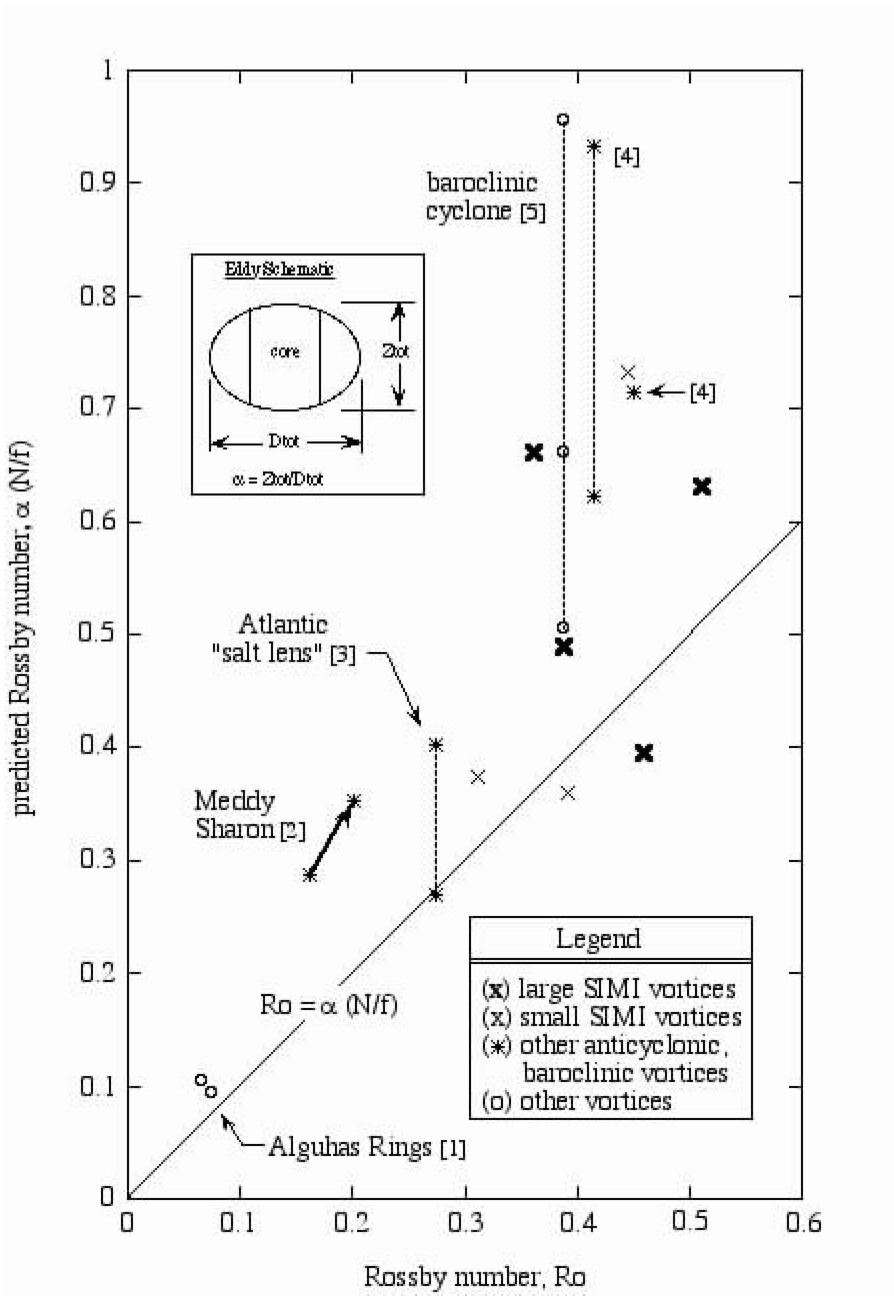

Figure 1. Predicted Rossby number vs. Rossby number for selected vortices. The predicted Rossby number is based upon the model of Gill [1981] for baroclinic, anticyclonic vortices formed by injection of fluid into a stratified background. The aspect ratio, a, is defined using the total diameter of each vortex [Hedstrom and Armi, 1988]. The evolution of Meddy Sharon during a year-long period is indicated by the arrow. The dashed lines represent uncertainty in measuring the dimensions of a given edd . The numbers in brackets refer to: (1) Olson, et. al., 1986, (2) Armi, et. al., 1989, (3) Riser, et. al., 1986, (4) D'Asaro, 1988a, and (5) Padman, et. al., 1990.

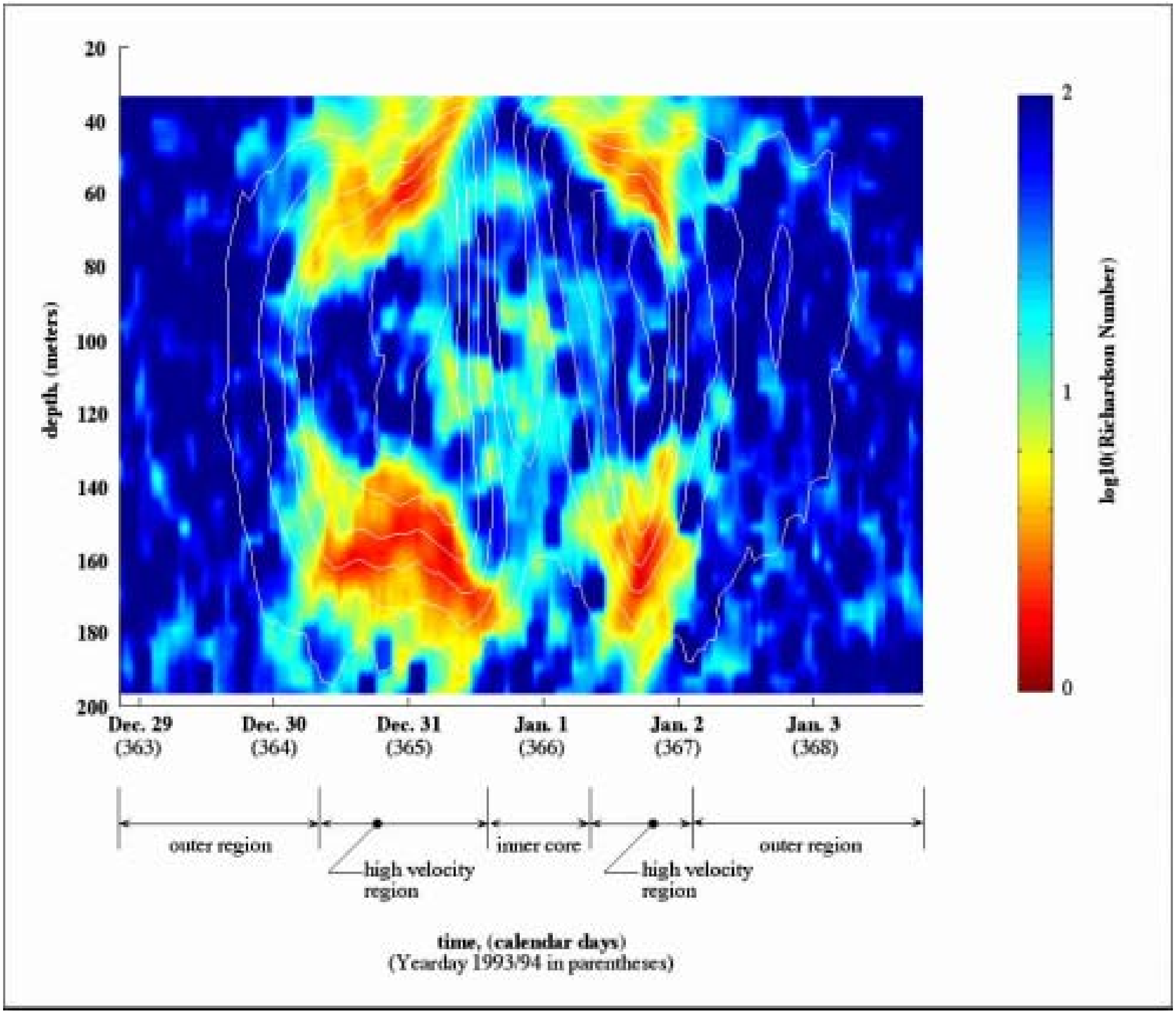

Figure 2. Depth/time map of Richardson number for eddy 6 (Dec. 31, 1993). The current speed contours (in white) are drawn every 5 cm/s for speeds between 10 and 35 cm/s. The Vaisala frequency was measured at the start of the SIMI drift (provided courtesy of J. Morison), and is a good match to climatology [Halle and Pinkel, in press]. The results are smoothed over 10 meters in depth and 3 hours in time. Richardson numbers less than 10 are found at shallow and deep depths of the high velocity region. The minimum Richardson number is roughly 1.3.